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Anonymous

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16. Abstract

The report describes the various physiological, biological, radio-biological, and radiation physics experiments to be conducted aboard the 1979 biological satellite. These experiments deal with the effects of space flight on living organisms, measurement of radiation, and possible methods of shielding space craft against such radiation.

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SCIENTIFIC EXPERIMENTS ON THE FLIGHT OF THE 1979 BIOLOGICAL SATELLITE (DRAFT PLAN)

Institute of Medical and Biological Problems,
USSR Ministry of Health;
Intercosmos Council, USSR Academy of Sciences

Introduction /1*

Biological research in space is an integral part of the scientific program for the further study and conquest of outer space. This research is aimed at studying the mechanisms used by living systems to adapt to a complex of factors present during space flight (primarily weightlessness) and at solving the problems caused by the radiation hazards of space flight -- the things needed to constantly improve the principles of and methods for medical and biological protection during extended manned space flight.

Four specialized biological satellites -- "Cosmos-605", "Cosmos-690", "Cosmos-782", and "Cosmos-936" -- were launched from the Soviet Union during the period from 1973 to 1977. On board the biosatellites were life forms of varying levels of complexity, from micro-organisms to mammals.

The results of this research showed that protracted weightlessness does not have a harmful effect on intracellular processes, even those associated with the transmission of hereditary information and the implementation of cell division.

Experiments using mammals (rats) produced no evidence of pathological changes caused by weightlessness.

In addition, a number of functional shifts associated with adaptation to weightlessness and readaptation to terrestrial gravity were noted during the studies on animals. They involved such things as:

*Numbers in the margin indicate pagination in the foreign text.

change in the animal's behavioral reactions and quiescent endurance limits; changes in metabolism and hormonal status; atrophy of certain muscle groups; osteoporosis and retardation of lengthwise bone growth; reduction in myocardial myosin adenosine triphosphate activity; reduction in erythropoiesis; aggravation of spontaneous hemolysis, etc.

Among the functional and structural changes manifest during post-/2 flight examinations of the animals, the major group consisted of nonspecific changes, enabling us to characterize the complex of factors present after the flight as the effects of stress. Among them are: increase in the functional activity of hypothalamic neurosecretory cells; adrenal hypertrophy; hypoplasia of lymphoid organs; change in the localization and content of mucopolysaccharides in the gastric mucosa, etc. Certain symptoms of stress-reactions have been noted in cosmonauts returning from flights of varying duration, but only experiments on animals have permitted an extensive enough view of the topography of changes taking place in various elements of the systems involved in the reaction.

Under the influence of weightlessness, significant changes took place in the locomotor systems of animals. Changes in the muscle system manifested themselves as muscle atrophy, decreases in strength and elasticity, spreading of connective tissue, and assorted metabolic alterations. Osteoporosis of the spongioid sections, moderate narrowing and thinning of the cortical laminae, slowing of periosteal osteogenesis and mineralization, slowing of lengthwise growth, and reduced mechanical strength appeared in the tubular bones. The severity of the changes may be adequately correlated with the extent to which the muscles take part in the implementation of anti-gravitational functions and the amount of gravity experienced by the bones while on Earth.

Studies of the modifying effect of weightlessness on the radiosensitivity of organisms have established that there is no difference between the genesis and course of radiation sickness in space and on Earth.

Research conducted during the flight of the "Cosmos-782" biosatellite, using an on-board centrifuge, showed that the effects /3 of artificial gravity in space are, in principle, the same as those of gravity on Earth, and was the first such research in the history of cosmonautics.

An on-board centrifuge for mammals was used in an experiment on the "Cosmos-936" biosatellite. The creation of a 1g artificial gravity in space to a considerable extent prevented the development of harmful weightlessness-induced changes in the body. It is particularly important to note the minimalizing effect of artificial gravity on the condition of the myocardium and the locomotor and excretory systems. Artificial gravity was an effective but not perfect prophylaxis for protracted weightlessness, since it had no normalizing effect on a number of indices characterizing the functional status of the body.

The possibility of producing and maintaining powerful electric fields for protection against cosmic radiation in protracted space flight was first demonstrated in experiments on biosatellites.

Specialists from Bulgaria, Hungary, Poland, Romania, Czechoslovakia, France, and the USA participated jointly with Soviet scientists in the accomplishment of biosatellite research.

Physiological, biological, radiobiological, and radiation-physics experiments will be conducted on the flight of the 1979 biological satellite.

The goal of the physiological experiments using rats on the 1979 biosatellite is further in-depth study of the mechanisms of adaptation to weightlessness and readaptation to terrestrial gravity /4 at the body, tissue, and cellular levels. An attempt will be made to evaluate the functional reserves of the hypothalamus-hypophysis-adrenal system, responsible for the nonspecific adaptive reactions of the body. A functional load test measuring stress (the "Stress" experiment) will be used for this purpose during the readaptation period.

A detailed study of the structure of animal bodies is proposed for the first time (the "Body Structure" experiment).

The volume of information about the condition of animals during flight will be expanded. It is proposed that evaluations of the ability of animals in weightlessness to react adequately to signals from the surrounding environment be conducted, and that information about the status of excitatory and inhibitory processes in the higher central nervous system be obtained (the "Behavior" experiment).

The "Biorhythm" experiment will permit us to obtain information about the state of the body's circadian rhythm and the rapidity of its phase reorganization during space flight.

New in principle will be the "Ontogenesis" experiment, which has as its goal determining the possibility of fertilization and fetal development in mammals during weightlessness. It is proposed that further stages of embryonal development after those begun in weightlessness be continued on Earth after the flight. Study of the basic body morpho-biochemical characteristics developed during space flight and evaluation of growth rates and possible developmental anomalies are planned.

Biological experiments in the following areas are proposed: /5

--a study of higher plant growth and development dynamics will be conducted using an on-board greenhouse;

--in a co-operative study with Czechoslovakian specialists, embryological studies using the "Inkubator" apparatus are planned;

--further study of genetic processes in drosophilae will be conducted using the "Bios-II" on-board installation.

In the radiobiological and radiation-physics experiments, study of the possibility of using electrostatic and dielectric protection in space flight and study of the effects of galactic-space radiation heavy nuclei on various bio-objects will be conducted.

The in-flight experiment will be accompanied by a synchronous terrestrial experiment in a model of the biosatellite; it will start 5 days after the beginning of the flight and will repeat all conditions of the in-flight experiment except weightlessness.

The first inspection of the biomaterial will be carried out immediately after the landing of the biosatellite. In order to accomplish this, a mobile laboratory complex, supplied with the necessary equipment, will be delivered to the landing site.

It is proposed that further research be carried out at scientific institutions in our nation and abroad. Besides Soviet specialists, scientists from Bulgaria, Hungary, the GDR, Poland, Romania, Czechoslovakia, France, and the USA will take part in examination of the bio-objects.

I. Physiological Experiments /6

The following physiological experiments on rats will be conducted on the biosatellite:

--the "Stress" experiment;
--the "Behavior" experiment;
--the "Biorhythms" experiment;
--and the "Ontogenesis" experiment.

Thirty-eight rats of the "Wistar" line, with no pathogenic microflora, will be placed on the biosatellite. These experimental animals will be provided by the Institute of Endocrinology, Slovakian Academy of Sciences (Czechoslovakia). Final selection of animals and their preparation for flight will be carried out at the Institute of Medical and Biological Problems, USSR Ministry of Health.

It is proposed that thirty rats be located in BIOS cage-blocks, analogous to those used previously; eight rats will be put in common cages of new construction (BIOS-vivaria) -- cf. the "Ontogenesis" section.

Individual cages will include a complex of life-support systems. Within each cage there will be a feeder, drinking bowl, an illumination device, a system of outlets for fresh air ventilation, a special slotted aperture for removal of body wastes, and cells for the storage of waste material over the entire course of the experiment, with separate collections for each two-day period.

Each cage is supplied with a special measuring device permitting calculation of all the movements made by the rats every day. A paste-like feed, specially developed for use in weightlessness, will be put in the feeder four times a day at six-hour intervals. Water intake during the flight will not be limited. Oxygen supply for the animals and removal of excess carbon dioxide and harmful gaseous impurities from the interior of the biosatellite's descent apparatus will be

accomplished by a system of chemical atmosphere regeneration. The temperature and humidity will be maintained by a thermo-regulation system with an atmosphere humidifier.

The distribution of the animals according to individual physiological experiments is shown in table 1; a list of the organizations taking part in the experiments is presented in table 2.

TABLE 1. EXPERIMENTS BEING CONDUCTED ON THE 1979 BIOSATELLITE

No.	Name of Experiment	Research Subjects
I.	PHYSIOLOGICAL EXPERIMENTS	
1.	"Stress"	Male rats No. 1 -- 20
2.	"Behavior"	Male rats No. 16-- 20*
3.	"Biorhythms"	Male rats No. 21-- 25
4.	"Body Structure"	Male rats No. 26-- 30
5.	"Ontogenesis"	Male rats No. 31 & 32
		Females No. 33-- 38

*Research will be carried out only during flight.

TABLE 2. LIST OF SCIENTIFIC INSTITUTIONS PARTICIPATING IN THE EXPERIMENTS ON THE 1979 BIOLOGICAL SATELLITE (PHYSIOLOGICAL RESEARCH)

No.	Name of Institution	Country
1.	Institute of Medical and Biological Problems, USSR Ministry of Health	USSR
2.	Institute of Evolutionary Physiology and Biochemistry, USSR Academy of Sciences	USSR
3.	Bach Institute of Biochemistry, USSR Academy of Sciences	USSR
4.	Pavlov Institute of Physiology, USSR Academy of Sciences	USSR
5.	Central Dental Research Institute, USSR Ministry of Health	USSR
6.	Priorov Central Institute of Traumatology and Orthopedics Research, USSR Ministry of Health	USSR
7.	Central Institute of Gastroenterology Research, Moscow Municipal Executive Committee of the Council of Workers' Deputies	USSR
8.	Institute of Medical Radiology, USSR Academy of Medical Sciences	USSR
9.	Institute of Nutrition, USSR Academy of Medical Sciences	USSR
10.	Sklifasovsky Central First Aid Institute, RSFSR Ministry of Health	USSR
11.	Institute of Cardiology, Armenian SSR Ministry of Health	USSR
12.	Bratislava Institute of Experimental Endocrinology, Slovakian Academy of Sciences	Czechoslovakia
13.	Shafarik State University, Kosice	Czechoslovakia
14.	Military Institute of Aviation Medicine, Warsaw	Poland
15.	Bucharest Institute of Physiology	Romania
16.	Institute of Roentgenology and Radiobiology, Sofia Medical Academy	Bulgaria

TABLE 1 (Continued)

No.	Name of Institution	Country
17.	Institute of Physiology, Debrecen Medical College	Hungary
18.	Institute of Pathophysiology, Debrecen Medical College	Hungary
19.	Szeged Institute of Biochemistry	Hungary
20.	Humboldt University	GDR
21.	NASA Ames Research Center	USA
22.	Department of Anatomy, Washington University	USA
23.	Aerospace Medicine Laboratory, Wright-Patterson AFB	USA
24.	Jet Propulsion Laboratory, Pasadena, California	USA

The "Stress" Experiment /11

The experiment is being conducted in order to study the mechanism of reaction to stress developing during space flight, as well as evaluation of the reserve capabilities of the hypothalamus-hypophysis-adrenal system of the body during the readaptation period.

We know that, among the changes appearing at postflight examinations of animals taking part in previous biosatellite experiments, the major portion consisted of nonspecific alterations which might be considered the effects of stress (adrenal hypertrophy, lymphoid organ hypoplasia, and many others). The research program in the upcoming experiment will be expanded, enabling us to discuss the mechanisms of stress-reaction development in certain systems. Hence, adrenalin, noradrenalin, and dopamine levels in certain nuclei of the hypothalamus, limbic system, [illegible], and truncus cerebri, and in various regions of the myocardium, etc., will be determined individually, and not in the organs as a whole, as was done previously.

In addition, a fixation stress test, which examines the condition of the hypothalamus-hypophysis-adrenal system like a functional test would, will be used for the first time during the postflight period of this experiment. This test will ascertain whether or not restructuring of adrenocortical reaction regulation occurs during the flight, similar to that occurring during the period of fixation stress (the virtual curtailment of hypercorticosteronemic reaction and premature return of corticosterone levels to initial values), repeated for several days. It will also determine whether or not the curtailed adrenocortical reaction in adapted animals is present 6 days after the end of the space flight; this will be important for evaluation of/12 the general health of cosmonauts.

The "Stress" experiment will use 20 animals in the flight group and as many in the synchronous terrestrial experiment and the vivarium control group. Apart from the research associated with the analysis of the stress-reaction mechanism, studies will be conducted to analyze

the mechanism of specific locomotor apparatus alterations occurring in weightlessness and examining various aspects of metabolism, etc.

In order to standardize the animals used for the experiment, a 2.5-hour fixation stress test will be done on them 12-15 days before the flight.

The animals will be divided into three groups: Group I (7 rats) will be sacrificed at the biosatellite landing zone immediately after landing (some manipulation will be performed before sacrifice). Group II (6 rats) will be sacrificed on the 6th day after landing. Group III (7 rats) will also be sacrificed on the 6th day after landing; all the animals in this group will undergo a postflight stress test (2.5-hour fixation stress), which will be done at the same time of day on days 1, 4, 5, 6,and 7 after the flight. Blood samples from these animals will be taken 20 min. before fixation, at the end of fixation, and 30 min. after its end on days 1, 4, and 6 after the flight. Group III animals will be sacrificed at the end of the fixation test done on day 7 after the flight.

The animals of all 3 groups will undergo postflight biochemical and morphological studies, using the program shown in table 3.

No.	Name of work. Organ or System studied. Indices.	Groups	Studied Material	Executor
1	2	3	4	5
	I. Central Nervous System			
1.	Determination of noradrenalin, adrenalin, dopamine, and serotonin content in certain nuclei of the hypothalamus, truncus cerebri, medulla oblongata, limbic system, cerebellum. Determination of glutamine, glutamic and aspartic acids, gamma-aminobutyric acid, polyamines, RNA, and sulfhydryl groups in the cerebral hemispheres and cerebellum.	1,2,3	entire brain	Czechoslovakia--Inst. Endocrinol.; USSR--R.A. Tigranyan, N.N. Demin.
2.	Determination of myokinase and phosphodiesterase activity in the hypophysis.	1,2,3	entire hypophys.	USSR--R.A. Tigranyan
	II. Endocrine Glands			
1.	Determination of adrenalin, noradrenalin, corticosterone, and aldosterone content; determination of enzyme activity, enzyme metabolism in the adrenals.	1,2,3	both adrenals, entire	Czechoslovakia--Inst. Endocrinol.; USSR--R.A. Tigranyan
2.	Study of iodized amino acid synthesis and determination of MAO activity in the thyroid gland.	1,2,3	entire thyroid	Czechoslovakia--Inst. Endocrinol.; USSR--R.A. Tigranyan
3.	Histological study of the testes and evaluation of the mutagenic influence of space flight on the sex glands.	1,2,4	1 entire testis	Bulgaria
4.	Study of the reaction of the testes to luteinizing hormone in the production of testosterone.	1,2,3	1 testis	Czech.--Inst. Endocrinol. USSR--R.A. Tigranyan
	III. Cardiovascular System			
1.	Determination of adrenalin, noradrenalin, and dopamine content in various parts of the myocardium.	1,2,3	entire myocardium	Czech.--Inst. Endocrinol. USSR--R.A. Tigranyan

TABLE 3 (Cont.)

No.	Name of work. Organ or system studied. Indices.	Groups	Stu Mat
	IV. Locomotor Apparatus		
1.	Study of glycerinized muscle fiber preparation contractility.	1,2,4	soleus (1/2 digitorum l brachialis, of triceps
2.	Study of the molecular composition of contractile and control muscle proteins.	1,2,4	soleus (1/2 digitorum l
3.	Study of the fractional composition of sarcoplasmic proteins.	1,2,4	soleus (1/2 digitorum l brachialis, of triceps
4.	Determination of electrolyte content and activity of a number of phospho-carbohydrate metabolism enzymes in skeletal muscles.	1,2,3	soleus (1/2 digitorum l plantaris, gastrocnemi
5.	Study of oxidation phosphorylation and glycolysis in skeletal muscles.	1,2,3,4	posterior m the thigh i
6.	Automated analysis of muscle fibers.	1,2,3,4	gastrocnemi plantaris,
7.	Evaluation of osseous tissue mechanical strength.	1,2,4	femur, head
8.	Quantitative analysis of certain parameters for bones.	1,2,3,4	tibia, radi
9.	Quantitative determination of the strength characteristics for isolated vertebrae.	1,2,3,4	vertebral c thoracic to
10.	Study of the mechanisms of calcification (de- and remineralization, recrystalization) in the bones.	1,2,3	femur*, sca parietal bo
10a.	Study of calcium metabolism using Ca^{40}.		ribs and in muscles

*After removal of marrow for studies V-5, 8.

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TABLE 3 (Cont.)

system studied.	Groups	Studied Material	Executor
ıber	1,2,4	soleus (1/2), extensor digitorum longus (1/2), brachialis, medial head of triceps	USSR--V.S. Oganov
tion of proteins.	1,2,4	soleus (1/2), extensor digitorum longus (1/2)	USSR--S. S. Oganesyan
ition of	1,2,4	soleus (1/2), extensor digitorum longus (1/2), brachialis, medial head of triceps	Hungary-- L. Kescius
ontent and o-carbohydrate muscles.	1,2,3	soleus (1/2), extensor digitorum longus (1/2), plantaris, diaphragm, gastrocnemius, quadriceps	USSR--V. P. Nesterov
tion and	1,2,3,4	posterior muscles of the thigh in entirety	USSR-- E. A. Kovalenko
ibers.	1,2,3,4	gastrocnemius, plantaris, quadriceps	USA--Castleman
echanical	1,2,4	femur, head of humerus	USSR--G. P. Stupakov
in	1,2,3,4	tibia, radius, humerus	USA--E. Holton
the strength ertebrae.	1,2,3,4	vertebral column (from thoracic to lumbar), tail	USA--L. Kazaryan
ification rystalization)	1,2,3	femur*, scapula, parietal bone	USSR-- A. A. Prokhonchukov
ing Ca^{40}.		ribs and intercostal muscles	USA--H. Cann

tudies V-5, 8.

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TABLE 3 (Cont.)

No.	Name of work. Organ or system studied. Indices.	Groups	S M
11.	Determination of citrate and glycogen content and the activity of a number of enzymes (alkaline and acid phosphatases, aldolase, alpha-amylase and pyrophosphatase) in osseous tissue.	1,2,3	tibia, rad
12.	Study of dentogenesis and osteogenesis in the rat jawbone.	1,2,4	jawbone
	V. Blood and Bone Marrow		
1.	Determination of the concentration of hormones, catecholamines, and lipids in blood plasma.	1,2,3	blood plas entirety
2.	Determination of the morphological composition of peripheral blood.	1,2,3	0.2 ml blo
3.	Determination of polydesoxyribonucleotides in erythrocytes.	1,2,3	1 ml erythr mass
4.	Study of hemoglobin structure.	1,2,4	1 ml erythr mass
5.	Quantitative cytological analysis of bone marrow.	1,2,3	femur
6.	Determination of maturation rates for bone marrow reticulocytes. Determination of DNA synthesis rates in bone marrow cells. Determination of hemoglobin content in individual erythrocytes. Study of electrophoretic mobility, configuration, and microstructure of erythrocytes.	1,2,4	sternum, 1 erythrocyte 2 blood sme
7.	Determination of lipid content in bone marrow.	1,2,3	humerus
8.	Determination of the mutagenic influence of space flight factors on bone marrow cells.	1,2,4	tibia
9.	Study of bone marrow truncus cells.	1,2,3	femur

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TABLE 3 (Cont.)

tem studied.	Groups	Studied Material	Executor
gen content zymes ldolase, in	1,2,3	tibia, radius, ulna	USSR--R.A. Tigranyan
esis in	1,2,4	jawbone	USA--D. Simmons
of hormones, d plasma.	1,2,3	blood plasma in its entirety	Czech.--Inst. Endocrinol.; N. Alers; USSR--R.A. Tigranyan
compo-	1,2,3	0.2 ml blood	USSR--L.V. Serova
leotides	1,2,3	1 ml erythrocyte mass	Czech.--E.Mish-urova
	1,2,4	1 ml erythrocyte mass	Czech.--N.A. Chernaya
of	1,2,3	femur	USSR--L.V. Serova
for bone on of DNA ls. Deter- individual retic mobility, of erythrocytes.	1,2,4	sternum, 1 ml erythrocyte mass, 2 blood smears	USSR--Central Hematology and and Blood Transfusion Research Institute; V.I. Korol'kov
bone marrow.	1,2,3	humerus	Czech.--I. Alers
luence of w cells.	1,2,4	tibia	Bulgaria
.	1,2,3	femur	Czech.--A. Bacek

TABLE 3 (Cont.)

No.	Name of work. Organ or system studied. Indices.	Groups	St Ma
	VI. Lymphoid Organs		
1.	Determination of lipid content in the thymus.	1,2,3	1/
2.	Determination of polydesoxyribonucleotides in the spleen.	1,2,3	1/
3.	Study of nucleic acid metabolism in the spleen.	1,2,3	2/
4.	Determination of thymocyte and splenocyte quantities.	1,2,3	1/ 1/
	VII. Connective Tissue		
1.	Quantitative and qualitative cytological analysis of connective tissue elements (mast cells, fibroblasts, and histocytes).	1,2,3,4	ski sub fat
2.	Study of connective tissue.	1,2,3	ski sub
	VIII. Liver		
1.	Study of enzymes participating in the transformation of carbohydrates into lipids.	1,2,3	4.3
2.	Study of carbohydrate and amino acid metabolism enzymes, lipogenic enzymes and enzymes participating in catecholamine destruction.	1,2,3	3.1
3.	Study of nucleic acid metabolism.	1,2,3	1.0
4.	Determination of lipid content.	1,2,3	300m
5.	Study of glucose metabolism.	1,2,3	500m

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TABLE 3 (Cont.)

system studied.	Groups	Studied Material	Executor
in the thymus.	1,2,3	1/2 thymus	Czech.--I. Alers
nucleotides	1,2,3	1/2 spleen	Czech.-- E. Mishurova
in the spleen.	1,2,3	2/5 spleen	USSR--I.A. Egorov
splenocyte	1,2,3	1/2 thymus 1/5 spleen	USSR--L.V. Serova
ological analysis last cells,	1,2,3,4	skin with subcutaneous fat	USSR--L.V. Serova
	1,2,3	skin with subcutaneous fat	Bulgaria
n the transform- ds.	1,2,3	4.3 g liver	USA--S. Abraham USSR--R.A.Tigranyan
acid metabolism nzymes partici- ion.	1,2,3	3.1 g liver	Czech.--Inst. of Endocrinology; USSR--R.A. Tigranyan
	1,2,3	1.0 g liver	USSR--I.A.Egorov
	1,2,3	300mg liver	Czech.--I. Alers
	1,2,3	500mg liver	Czech.--Inst. of Endocrinology; USSR--R.A. Tigranyan

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TABLE 3 (Cont.)

No.	Name of work. Organ or system studied. Indices.	Groups	Stu Mat
	IX. Excretory System		
1.	Evaluation of enzymatic and osmotic conditions of renal concentration activity. Study of kidney ionic composition.	1,2,3,4	1 entire ki papillary
2.	Evaluation of kidney tissue hydration.	1,2,3,4	1/3 kid
	X. Adipose Tissue		
1.	Determination of lipid content in brown adipose tissue.	1,2,3	entire brow tissu
2.	In vitro study of the action of noradrenalin in the elimination of fatty acids from adipose tissue.	1,2,3	epididymal tissue -- 2
3.	Determination of lipogenetic enzyme concentration in adipose tissue.	1,2,3	epididymal tissue -- 1
	XI. Gastro-intestinal Tract		
1.	Physiologo-biochemical and morphological studies of the gastro-intestinal tract.	1,2,3,4	salivary gla stomach, par small intest entire lungs
	XII. Sense Organs		
1.	Cytological studies on the corneal epithelia of the eye.	1,2,3,4	eyes

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TABLE 3 (Cont.)

system studied.	Groups	Studied Material	Executor
smotic conditions cy. Study of	1,2,3,4	1 entire kidney, 2nd papillary zone	USSR--M. Natochkin
dration.	1,2,3,4	1/3 kidney	USSR--A.S.Pannova
t in brown adipose	1,2,3	entire brown adipose tissue	Czech.--I. Alers
of noradrenalin cids from	1,2,3	epididymal adipose tissue -- 200 mg	Czech.--Inst. of Endocrinology; USSR--R. A. Tigranyan
enzyme concentration	1,2,3	epididymal adipose tissue -- 1.0 g	Czech.--Inst. of Endocrinology; USSR--R. A. Tigranyan
Tract			
rphological studies t.	1,2,3,4	salivary glands, stomach, pancreas, small intestine entire lungs	USSR--K. V. Smirnov Romania-- P. Groza
rneal epithelia	1,2,3,4	eyes	USSR--F. V. Sushkov; S. V. Rudneva

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The "Behavior" Experiment /19

The "Behavior" experiment is being conducted to study the peculiarities of the functional status and efficiency of the higher central nervous system in animals during space flight.

The great efficiency noted in practically all cosmonauts on extended flights was stimulated to a considerable extent by their feelings of duty and responsibility, and ensured by the excitement and mobilized reserves of the body. This increase in efficiency may be occurring within a framework of asthenization and nervous exhaustion. In this connection, obtaining corresponding data on animals free from social strictures and pharmacological influences becomes quite important, since it allows us more objectively to evaluate central nervous system reserves and mental efficiency, especially in situations where time is critical and during emergencies.

Research previously conducted has shown that, after exposure of white rats to conditions on the "Cosmos" biological satellites, their ability to reach goals in varyingly complex mazes decreased. The number of refusals to negotiate mazes, the time utilized to complete them, and the number of mistakes made during the negotiation all increased. Poorer performance dynamics were also noted in the experiments, a neurotic state was more often manifest, and activity during the heightened functional load on the nervous system decreased. Study of the functional status of the higher areas of the brain immediately after flight will enable us to define the roles of flight and subsequent readaptation to terrestrial conditions in the formulation of some of /20 the alterations noted above. There is no information at all in the literature concerning the dynamics of animal brain nervous processes during extended space flights; an attempt must first be made to perform such studies.

The experiment will be conducted using 5 male rats placed in the BIOS-N aboard. Animals from the synchronous experiment and animals contained in the vivarium will be used as controls.

The conditioned-reflex method is most preferable for the on-board experiments using mammals, since it is sensitive to the effects of external factors, is feasible within a limited area, and, mainly, permits adequate evaluation of the functional status of higher brain centers. The stereotype commonly used is from 8-14 conditioned stimuli given the animal during a 10-15 minute period. The stereotypes are altered by changing the signal strength, serial order, or duration of the stimuli during the set period.

At this stage of the work, the minimal program will be employed, according to which the animals' conditioned reflex activity will be studied by their presenting the previously developed stereotype from 2 positive signals (differing physical strengths) and one differentiating signal. The cyclogram of signal presentations is associated with the animals' feeding periods; reinforcement of positive stimuli is produced by regular feeding.

A conditioning light signal is given after the pump stops working and immediately before the feeder opens. The duration of its isolated presentation is 4-6 seconds. During the following 19-21 seconds the action of the conditioning signal coincides with the opening of the feeder. The initiation of a purposeful movement towards the feeder during the 8-9 seconds after the beginning of the signal is considered the animal's response to the conditioning signal (i.e., the presence /21 of the conditioned reflex).

The duration of the differentiating stimulus is 7 seconds. Inasmuch as it is given in the period between feedings, it is not accompanied by additional aural signals. Total absence of an active feeding reaction in response to the signal given (during the 8-9 seconds after its beginning) would be evidence of differentiation consolidation.

The parameters of the conditioned reflexes (latent period, strength), the number of inter-signal reactions, the status of strength ratios, etc., are determined by the nature of the animal's general motor activity near the feeder. The space between the beginning of the

conditioning signal and manifestation of feeding motor activity determines the value of the latent period, and the electroactivity integral during this reaction determines the strength of the reflex.

A secure animal containment unit, permitting the performance of the research program, was designed for this experiment. Its construction is essentially the same as that used on the "Cosmos-782" and "Cosmos-936" satellites.

A second light source, placed on the back cover of the cage, and a system for recording the animals' activities near the feeder are included in the unit for special purposes.

Both light sources are used to deliver stimuli to the animals using 3 regimes:

Regime 1 -- a double light intensity, light flashing at 2 hz; strong conditioning signal.
Regime 2 -- a double light intensity, light not flashing; weak conditioning signal. /22
Regime 3 -- a double light intensity, light flashing at 4 hz; differentiating signal.

A photoresistor is used as a sensor to record the animals' activities near the feeder.

The possibility of recording signal analogs of the animals' spontaneous motor activity in the cages and the motor activity characterizing the behavior of an animal near the feeder is envisioned.

The principle used to record motor activity is analogous to that used previously.

Insofar as the peculiarities of conditioning signal stereotype preservation and perfection are being studied, provision, inter alia, for extensive special preparation of the animals during the preflight period is being made (table 4).

TABLE 4. GENERAL TIME SCHEME FOR PREPARATION AND CONDUCTING OF EXPERIMENT

	Days	Nature of Task
PREFLIGHT	25 -- 23	General training of animals for stay in installation.
	22 -- 17	Development of positive conditioned reflex to set strong stimulus.
	16 -- 9	Development of positive conditioned reflex to set weak stimulus.
	8 -- 5	Introduction of differentiating signal into the stereotype.
MIDFLIGHT	1 -- 20	Presentation of stereotype according to set program: positive strong signal 2 times a day, positive weak signal 2 times (before opening of feeder at feeding time) and differentiating signal 2 times (2 hours before regular feeding daytime and nighttime).

The results of the experiment (when compared with the terrestrial one) will permit evaluation of basic nerve process features (their strengths, mobilities, mutual compensations, etc.) directly from flight, and tracing of the dynamics of adaptation to the influence of the factors accompanying it. /23

Deterioration of some conditioned reflex activities (increased latent reflex periods, altered strength ratios, disinhibition of differentiations) are possible in the initial period of flight. Later on, signs of adaptation processes and gradual normalization of higher nervous activity obviously will appear.

N. B.:

To obtain the full range of expected information, precise working of the life-support system and apparatus recording motor activity

near the feeder will be necessary. Technical flaws in the systems will be noticeably reflected in the data from the experiment.

The "Biorhythms" Experiment /24

The goal of the experiment is the study of the influence of weightlessness and other factors of space flight on the rate of phase restructuring, stability, and rhythm structure of some physiological processes.

Data from the medical control of cosmonaut condition, as well as results of physiological studies done in biosatellites, have shown evidence of changes in the characteristics and interrelationships of periodic processes in the body during the course of protracted space flight. This primarily refers to circadian rhythms, which are most accessible to observation during flight and most important for evaluating the condition of the body in these situations.

According to recent data, the role of time-sensor may be played not only by light, temperature, and pressure, but also by geophysical factors: magnetic and electrical fields. It is presumed that, in space flight, the structure of circadian rhythms changes and the rapidity of their phase restructuring decelerates in connection with changes in a number of geophysical variables.

Desynchronization and lengthening of circadian rhythm phase restructuring may also occur during flight as a result of the stressful effect of weightlessness and other flight factors. Manifestations of desynchronization in animals experiencing stress, in particular hypokinetic stress, can precisely be established by changes in the transient rhythms of physiological processes.

The results of biorhythm research conducted on piloted flights can be supplemented and expanded by material obtained in experiments done on animals in biosatellites. The results obtained in the latter case are not complicated by the interference of social, motivational, and emotional factors, which is extremely important for research into /25
the mechanisms of weightlessness' effects on circadian rhythms. The definite methodological advantages of conducting such experiments on animals are obvious.

An inverse ratio between the dynamics of average daily body temperatures and motor activity in rats during the course of the animal's adaptation to weightlessness over the entire period of a flight were shown in an experiment on the "Cosmos-782" biosatellite. In addition, a normal distribution of these figures within the limits of the daily cycle was established.

Investigation into the status of the circadian periodicity of physiological processes will be conducted in an experiment on the 1979 biosatellite, using the indices of the animals' motor activity and body temperatures. The values for the cited indices will be studied as functions of time and analyzed as characteristics of temperature homeostasis and motor functioning of the body during weightlessness.

Analysis of the results from the standpoint of the thermodynamics and kinetics of non-equilibrium systems permits study of the entire complex of investigated phenomena, including changes in motor function and body temperature associated with the periodics of their alterations.

Both indices will be recorded from 5 animals on the flight and the same number in the synchronous experiment and in the vivarium controls.

The standard BIOS unit, similar to those used on previous biosatellites, will be used to contain the experimental animals. Circadian periodics in the remaining animals kept under similar conditions in flight and in the synchronous experiment will also be evaluated, but by motor activity alone.

Prior selection of the rats for the flight and synchronous experiments, according to types of nervous activity, will be carried out using the "in the field" method. /26

In the pre- and post-experiment periods, just as in flight, all animals will be kept in 12 hours of "light" and 12 hours of "darkness."

To obtain information about the effects of these conditions on the rapidity of adjustment for the parameters being studied to external time-sensors in comparison with terrestrial conditions, a photoperiod phase shift will be performed in the containment units of 5 animals (one "BIOS" unit) in the flight and synchronous experiments. To accomplish this, one of the "light" or "dark" periods in the middle of the flight will be extended by 12 hours, and thus the photoperiod phase will be shifted 180°. In the remainder of the BIOS, lighting periods will remain unchanged. After the flight and synchronous experiments, a second photoperiod phase shift of 180° should be performed in order to study the influence of readaptation on the rapidity of circadian rhythm restructuring.

In addition to the status of initial and postexperimental circadian rhythm, transient stimulus-response activity rhythms in the animals will be studied before and after the flight, using a methodology developed by specialists in the GDR. According to this method, a mechanical reflex to painful reinforcement is produced, and the latent period and time of lever displacement (without reinforcement) is then determined every 30 seconds. Experience has shown that the value of the cited indices changes periodically (the normal period is 5-7 minutes). The oscillation period and amplitude depend on the time of day, but the phase coincidence of these processes is a sensitive indicator of /27 stress. The operation will be carried out with the aid of a special device developed and prepared by specialists from the GDR. Determination of excreted catecholamines and some electrolytes in the rats' urine will be conducted by GDR specialists in the postexperiment examinations. Round-the-clock urine tests for these analyses will be performed simultaneously with balancing studies conducted using cages specially intended for this.

The animals designated for the "Biorhythms" experiment will be the only group kept alive for readaptation during the 25-day period after the end of the flight. Therefore, some observations not directly associated with the solution of the biorhythm problem will be done on these (5) rats. Studies on vestibulo-motor reactions belong here.

Also to be conducted within this framework are: a study of the postures and movements of the animals recorded on film; a Magnus vestibulo-spinal reflex study; electromagnetic study of the lift reflex; electro-myographic study of the nystagmus reaction and evaluation of the animals' static strength.

Finally, measurement of the energy-metabolism of the animals in this group will be performed using gas analysis of enclosed space air.

TABLE 5. PRE- AND POST-FLIGHT PHYSIOLOGICAL STUDIES IN THE "BIORHYTHM" EXPERIMENT*

No.	Types of Studies	Period Covered	Number of Animals	Executor
1.	Circadian rhythm study	Day 21, 22 before flight	20	Inst. of Med. & Biol. Probs., USSR Minis. of Health
		Day 1, 9-10, 16-17, 23 after flight		
2.	Transient rhythms study:			
	1. Training	Days 17-13 before flight	20	Humboldt University (Nervous Disease Clinic, Dept. of Neuropath.) GDR
	2. Study	Days 12-11 before flight	20	
		Day 4, 5, 11, 15, 20 after flight	10	
3.	Catecholamine and electrolyte excretion studies	Day 0, 3, 8, 14, 19 after flight	10	Military Inst. of Aviat'n Med. Poland
4.	Balance studies	Day 0, 3, 8, 14, 19 after flight	10	IM&BP, USSR Minist. of Health
5.	Vestibulo-motor reactions studies	Day 9, 10 before flight	20	IM&BP, USSR MH
		Day 2, 4, 6, 7, 12, 13, 21, 24 after flight		
6.	Gas metabolism studies	Day 9 before flight	20	IM&BP, USSR MH
		Day 2, 5, 11, 15, 21 after flight	10	

*On the "flight" group of animals. Analogous studies on animals in the synchronous study will be done with a 5-day displacement.

The "Body Structure" Experiment /29

The goal of the experiment is the determination of the influence of a 20-day biosatellite flight on the mass and structure of the following components of the body: lean mass of body, musculo-skeletal system, liver, spleen, gastro-intestinal tract, kidneys, heart, lungs, skin, adrenals, sex glands, and central nervous system (brain and spinal cord).

Numerous experiments conducted by various scientists have shown the influence of weightlessness in decreasing the participation of the musculo-skeletal system in locomotion and posture support, leading to muscular atrophy, demineralization of osseous tissue, and to decrease in body mass. Reduction in body mass may be associated both with decreased adipose tissue mass, which proves extremely mutable, and with reduced lean body mass, which is possibly the result of a disturbance of protein synthesis in the tissues of various organs.

5 male rats are to be used for the experiment. Dissection of the animals is to be performed 1-2 weeks after completion of the flight at the USSR Ministry of Health Institute for Medical and Biological Problems.

After sacrifice, incisions will be made as close as possible to the tissue integument, and the contents of the gastro-intestinal tract will be extracted. The skin will then be removed and the heart, liver, gastro-intestinal tract, kidneys, spleen, lungs, adrenals, sex glands, brain, and spinal cord will be extracted.

The total mass of all the prepared components will be compared with the overall pre-preparation mass.

The water content in each isolated organ and in the musculo-skeletal system will be determined by leophilization and the fat content by direct extraction using petroleum ether in a Soxhlet's /30
apparatus. After this, the dried organs, free of fat, will be carefully

pulverized, the protein content will be determined using the [Culdall] method, and the Ca, K, Na, and Mg content by atomic spectrophotometry. Some biochemical indices of the blood will be ascertained.

The following indices will be computed during processing:

1. Corrected live mass (mass after sacrifice plus mass of blood minus mass of fur and contents of the gastro-intestinal tract).

2. Lean body mass: mass of the body less mass of lipids extracted from the various components.

3. Musculo-skeletal system with lean body mass correction.

4. Content of fat, water, protein, K, Ca, Na, and Mg in each component and in the corrected live mass.

The "Ontogenesis" Experiment /31

The goal of this experiment is to determine whether or not fertilization and fetal development is possible in mammals during weightlessness. The intent is to obtain offspring (on Earth, after completion of the flight) following embryonal development in weightlessness, to evaluate the condition of internal organs in the newborn, to discover any developmental anomalies, and to evaluate growth rate and viability.

Previous experiments done in biosatellites have shown that space flights of up to 22 days do not cause pathological alterations in the bodies of healthy adult male rats. At the same time, reversible metabolic changes were noted in a number of organs and systems, principally the locomotor apparatus, myocardium, and others.

There is a basis for the presumption that pregnant female rats and the developing embryos are more sensitive to the influence of flight factors, most of all weightlessness, than are adult males.

Inasmuch as "while being protected by its mother, the embryo also is subject to unfavorable influences from the mother's body, to its biochemical, immunological, and hormonal disturbances" (G. Korner), we might think that, during space flight, the essential influences on embryonal development are changes in the hormonal status of the mother's body, disturbances of calcium metabolism, changes in the eythrocyte system, and some others.

A cage system based on the design of the previously used BIOS /32 device will be used for the group containment of animals during the flight (BIOS-vivaria). The cage has a volume of about 25 liters, divided by an opaque partition into two unequal sections: 6 males are kept in the larger and 2 females in the smaller. There are two apertures in the partition which will open upon command from Earth on the second day of the flight. Thus, if the flight lasts 20 days, the first offspring will be obtained on the 3rd or 4th day after return to Earth, inasmuch as intrauterine development in rats lasts 21 days*.

*If fertilization does not take place in flight, it is proposed that it be accomplished on Earth after the flight,

After completing the flight and obtaining the offspring, the following tasks will be carried out:

--examination of the newborn rats, males and females (for appearance of possible developmental anomalies; evaluation of internal organ condition using morphological, cytochemical, and biochemical methods);

--observation of the rats, males and females, which developed in weightlessness for a period of 8-10 weeks following birth (study of growth and development rates, evaluation of viability according to autodefense and reactivity);

--examination of the rats developed in weightlessness after they are fully grown (evaluation of hormone status; study of the condition of organs and systems reacting specifically to weightlessness -- such as muscles, skeletal apparatus, erythron, myocardium);

--obtaining offspring by interbreeding males and females which /33 underwent intrauterine development in weightlessness, as well as interbreeding of adult rats who were on the flight with the control rats (males and females). Appearance of possible developmental anomalies in the offspring thus obtained and evaluation of their viability and growth rates.

A diagram of this work with animals during and after flight is presented in tables 6, 7, and 8.

The animals kept in the vivarium and the animals from the synchronous experiment in the biosatellite model on Earth will serve as controls.

TABLE 6. BASIC STAGES OF WORK WITH ANIMALS IN THE "ONTOGENESIS" EXPERIMENT (IN FLIGHT AND AFTER COMPLETION)

No.	Title of Work	Group Number	Periods
1.	Union of males and females into one group.	1	3rd day of flight
2.	Sacrifice of newborn rats borne by females of the flight group (generation I)	2	from 4th day after flight*
3.	Verification of ovulation cycles in females which were on flight.	1	5-6 weeks after offspring birth
4.	Fertilization of flight group females by control males.	1_K	5-6 weeks after offspring birth
5.	Examination of rats born of flight group females after reaching maturity.	3,4	8-10 weeks from day of birth
6.	Interbreeding of males and females from first generation of offspring.	4	10 weeks from day of birth
7.	Sacrifice of male and female adults from first generation of offspring.	3	8-10 weeks after day of birth
8.	Sacrifice of newborn rats from flight group females fertilized by control males -- generation Ia (cf. No. 4).	5	immediately after birth
9.	Observation of generation Ia offspring before reaching full maturity.	6	8-10 weeks from day of birth
10.	Sacrifice of male and female animals from generation Ia.	6	8-10 weeks after day of birth
11.	Sacrifice of newborn rats obtained from offspring of flight group animals -- generation II (cf. No. 6).	7	immediately after birth
12.	Observation of generation II offspring until reaching full maturity.	8	8-10 weeks from day of birth
13.	Sacrifice of adult generation II animals.	8	8-10 weeks after day of birth

*with a flight duration of 21 days.

N. B.: If a large number of newborn are obtained from each generation, the number of sacrifices will be increased. In this case, besides the periods noted in the table, sacrifices will be done on the 14-16th and 30th days after birth.

TABLE 7. DISTRIBUTION PLAN FOR ANIMALS FROM THE "ONTOGENESIS" EXPERIMENT

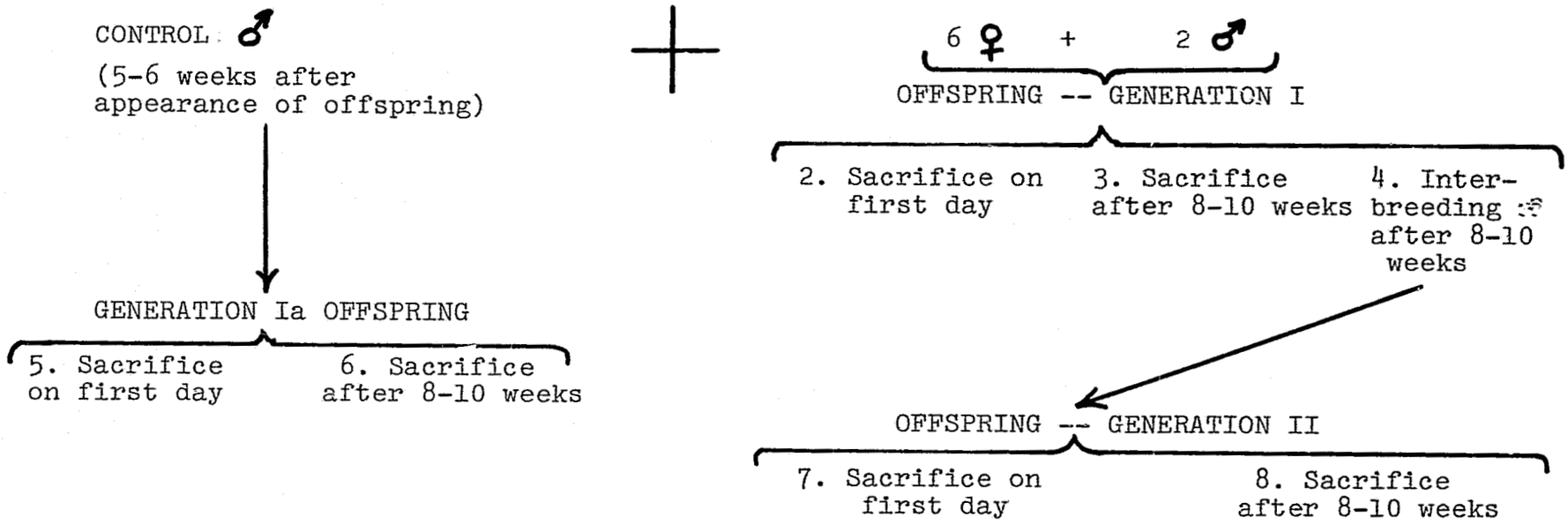

TABLE 8. "ONTOGENESIS"

No.	Organ, system. Indices being studied.	Group of Animals		Quantity of Material
1.	Computation of number of newborn, sex, body and organ weights.	2,5,7		
2.	Examination, photographing of newborn; calculation of visible developmental defects.	2,5,7		
3.	Study of embryonal and postnatal bone development.	2,5,7 3,6,8	(A)	1 hind limb
4.	Study of osseous tissue using histological and morphometric methods.	2,5,7 3,6,8	(A)	1 hind limb
5.	Biophysical studies of osseous tissue.	2,5,7 3,6,8	(B)	1 femur
6.	Study of degree of muscle differentiation on the basis of weight and contractility.	2,5,7 3,6,8	(B)	skeletal muscles of 1 fore and 1 hind limb
7.	Electron microscope studies of muscles and nerve-muscle endings.	2,5,7 3,6,8	(B)	soleus and quadriceps, diaphragm
8.	Study of analyzer development.	2,5,7 3,6,8		in newborn--entire head; in adult--the brain
9.	Electron microscope studies of adrenals.	2,5,7 3,6,8	(A)	1 adrenal
10.	Determination of catecholamine content in adrenals.	2,5,7 3,6,8	(B)	2 adrenals
11.	Determination of corticosterone, tyrosine, cholesterol, triglyceride, and non-esterified fatty acid content in blood serum.	3,6,8		0.6 ml serum
12.	Determination of catecholamine content in the myocardium.	2,5,7 3,6,8		myocardium

TABLE 8. "ONTOGENESIS"

studied.	Group of Animals		Quantity of Material	Executor	Notes
ex, body	2,5,7			USSR, L. V. Serova	
rn; l defects.	2,5,7			USSR, N. A. Chel'naya	
ne development.	2,5,7 3,6,8	(A)	1 hind limb	USA, E. Holton	
logical	2,5,7 3,6,8	(A)	1 hind limb	USSR, V. S. Yagodovsky	
ne.	2,5,7 3,6,8	(B)	1 femur	Poland, K. Ostrovsky	
lation lity.	2,5,7 3,6,8	(B)	skeletal muscles of 1 fore and 1 hind limb	USSR, V. S. Oganov	
les	2,5,7 3,6,8	(B)	soleus and quadriceps, diaphragm	Poland, V. Stodolnik-Baranskaya	Muscles with limbs used in No. 5
	2,5,7 3,6,8		in newborn--entire head; in adult--the brain	USA, R. Keith	
als.	2,5,7 3,6,8	(A)	1 adrenal	Poland, V. Stodolnik-Baranskaya	
nt in	2,5,7 3,6,8	(B)	2 adrenals	Czech., Inst. Endocrinology	1 adrenal, if number of animals lmtd.
osine, sterified	3,6,8		0.6 ml serum	Czech., Inst. Endocrinology	
nt in	2,5,7 3,6,8		myocardium	Czech., Inst. Endocrinology	

TABLE 8 (Cont.)

No.	Organ, system. Indices being studied.	Group of Animals	Quantity o Material
13.	Study of lipogenesis in the liver and lipolysis in white and brown adipose tissue.	3,6,8	1 g liver, 0.5 g fat
14.	Morphological studies of the ovaries.	3,6,8	ovary
15.	Histological and cytological studies of the testes.	3,6,8	testis
16.	Cytological analysis of the blood and bone marrow; determination of erythrocyte and leukocyte resistance.	2,5,7 3,6,8	0.3 ml blood
17.	Cytogenetic analysis of bone marrow.	3,6,8	tibia
18.	Cytological analysis of lymphoid organs and connective tissue.	2,5,7 3,6,8	skin and subcutaneous tissue; thymu spleen
19.	Study of enzymes in the liver and kidney.	2,5,7 3,6,8(B)	liver, kidney
20.	Study of kidney ion composition.	2,5,7 3,6,8	1 kidney
21.	Observation of growth and development rates, general condition and behavior of animals; functional tests to evaluate changes in resistance and reactivity with age.	3,4,6,8	continuous observation
22.	Study of water-electrolyte metabolism using loading tests.	3,4,6,8	continuous observation

FOLDOUT FRAME

TABLE 8 (Cont.)

studied.	Group of Animals	Quantity of Material	Executor	Notes
and lipolysis	3,6,8	1 g liver, 0.5 g fat	Czech., Inst. Endocrinology	
es.	3,6,8	ovary	Poland, V. Stodolnik-Baranskaya	
es	3,6,8	testis	Bulgaria, A. Vyglenov	
and bone te and	2,5,7 3,6,8	0.3 ml blood	USSR, L. V. Serova	
w.	3,6,8	tibia	Bulgaria	
rgans	2,5,7 3,6,8	skin and subcutaneous tissue; thymus, spleen	USSR, L. V. Serova	
kidney.	2,5,7 3,6,8 (B)	liver, kidney	USA, S. Abraham	
	2,5,7 3,6,8	1 kidney	USSR, Yu. V. Natochin	
ent rates, animals; es in	3,4,6,8	continuous observations	USSR, L. V. Serova; Poland, S. Kozlovski	
ism using	3,4,6,8	continuous observations	USSR, Yu. V. Natochin	

FOLDOUT FRAME 2

TABLE 8 (Cont.)

No.	Organ, system. Indices being studied.	Group of Animals	Quant: Mate
23.	Study of conditioned and non-conditioned reflex reactions in the nervous system.	3,4,6,8	contir obser
24.	Verification of adult rat ovulation cycles (by studying vaginal smears).	1,3,4,6,8	Vagina

N. B. Inasmuch as the demand for organs to use in experiments exceeds the which may be obtained from a single animal, it is proposed that 10 2 groups -- A and B -- be sacrificed each time; in those cases whe are not being conducted, researchers will receive material from al

FOLDOUT FRAME

TABLE 8 (Cont.)

ɔeing studied.	Group of Animals	Quantity of Material	Executor	Notes
-conditioned ɔus system.	3,4,6,8	continuous observations	USSR, Z. I. Apanasenko	
ulation cycles .	1,3,4,6,8	Vaginal smear	USSR, N. A. Chel'naya	

rgans to use in experiments exceeds the supply of material single animal, it is proposed that 10 animals, divided into crificed each time; in those cases where parallel experiments earchers will receive material from all 10 animals.

FOLDOUT FRAME 2

II. Biological Experiments

/39

Along with the physiological studies on small laboratory rats to be conducted in the next 1979 biological Earth satellite, a number of general biological experiments are planned for further study of the peculiarities of growth, development, morphology, and structuro-physiological conditions of the body during weightlessness.

The following experiments have been planned:

--Gravitational preference;
--"Avian embryogenesis";
--"Higher Plants";
--"Mammalian Tissue Culture";
--"Somatic Embryogenesis of Plants";
--"Crown Galls of Carrots."

Successful completion of the experiment will permit further extended study of the mechanisms of the influence of weightlessness and terrestrial gravity on biological systems.

1. "Gravitational Preference" /40

Biosatellite flights make it possible to clarify what gravitational forces animals prefer for their development and vital activity. At the theoretical level, this question helps us better understand the evolutionary significance of gravitational force, and at the practical level it bears directly upon the technical conditions for developing on-board life support systems.

A centrifuge, the rotation of which will create centrifugal gravity forces of up to 1g, will be used for the study of on-board gravitational preference. The drosophila fruit fly will be used as the subject.

A mother culture, prepared before the launch of the biosatellite, will be placed at the center of the centrifuge, i.e., at an acceleration of about 0g, with the culture timed such that "takeoff" of the adult flies will begin on approximately the 8th day after launch. The centrifuge has 4 tunnels made of transparent material. 3 troughs are to be placed in each tunnel for egg laying and the development of the first generation of flies. The troughs are to be placed at levels whose intervals from the axis of rotation correspond to accelerations of 0.2, 0.6, and 1g, created by the rotation of the centrifuge.

Gravitational preference will be determined by the quantity of eggs laid in the troughs distributed at the 3 differing levels of g. Naturally, not only eggs, but also larvae and pupae will be counted. "Takeoff" of the first generation of adult flies from the troughs must not occur during the flight of the biosatellite.

Besides determining the gravitational preference of the flies, the parent drosophilae and the first generation will be subjected to /41 genetic and morphological studies.

An alternative scheme may, in principle, also be used for the experiment, so that the flight of the flies from the mother culture will begin immediately after insertion of the satellite into orbit, but the parent flies and the first generation will vary in phenotype.

Postflight research on the obtained material will be done under laboratory conditions using genetic methods.

2. "Avian Embryogenesis" /42

We know that the early (embryonal) period of organismal development is most sensitive to changes in the surrounding milieu. In studies done in the "Cosmos-782" biosatellite by the Institute for Medical and Biological Problems, in co-operation with specialists from the Department of Embryology at the Lomonosov Moscow State University, it was shown that weightlessness and compensated gravity force conditions cause a number of disorders in the course of embryonal development during its early stages (cleavage and gastrulation). With the co-operation of specialists from Czechoslovakia and the participation of US specialists, an experiment designed to study the course of avian embryological development in weightlessness is being planned for the next biological Earth satellite in 1979. The experiment will be conducted using eggs from the Japanese quail. The choice of this subject was dictated most of all by its good coverage in previous studies, small size, and prospects for using this species as a link in the biological life support system.

The experiment will be carried out using an on-board incubation device, developed in Czechoslovakia, which has a 60-egg capacity. Incubation will go on for 12 days of the flight at $t^\circ = 37 \pm 1^\circ C$ and a humidity of $70 \pm 10\%$. Immediately after termination of the flight, part of the eggs will be fixed. The remainder of the eggs will be incubated until the expected hatching of the chicks, i.e., tentatively before the 6th day after landing.

After landing, a part of the material must be fixed immediately for histological analysis, and the other part fixed as the chicks hatch. In the postflight studies, particular attention will be paid to the structure of the otolithic apparatus and the sections of the brain and musculoskeletal system associated with it. In addition, study of rates of embryogenesis and growth dynamics in weightlessness, as well as /43 possible remote consequences of space flight factors on first and second generation adult birds is proposed.

3. "Higher Plants"

Experiments on higher plants occupy an important place among the /44 biological experiments done aboard space craft. Results of these experiments have shown that weightlessness, as one of the basic factors of space flight not, in principle, presenting any hindrance to the growth and development of vegetable organisms, may also cause some changes in both the morpho-physiological and structuro-metabolic condition of plants. In particular, deviations in plant organ orientation, rapidity of plant growth, size and shape of cells comprising the tissues of various parts, as well as changes in the ultrastructural organization of meristem cells and cell organelles have been manifested during the process of the research.

Study of the influence of space flight factors, chiefly weightlessness, on the structural organization and functional activity of higher plants will be continued in the 1979 biological satellite. A biological research device (BBI-1), and an on-board greenhouse designed for automatic cultivation of higher plants from dried seeds during weightlessness will be installed aboard the biosatellite in order to carry out the experiment.

The basic goal of the experiment is the study of the influence of weightlessness on the dynamics of growth and the organization and movement of plant organs; the study of the nature and features of plant cell organelle, tissue, and organ origin and formation. The proposed subjects of the study are maize, arabidopsis, Peking cabbage, flax, etc.

The "BBI-1" installation consists of the following basic parts: /45 lighting system, vegetation bath, water supply tank, primary substrate wetting pack, and time-lapse camera and film pack.

In the preflight preparation period, the vegetation bath apparatus is filled with a dry substrate containing a collection of the mineral elements needed by plants (Hoagland medium), in which the sowing of the dry seeds is to take place. The appropriate volume is then filled with

distilled water and the motion picture cameras are loaded with film (16-mm). The apparatus is automatically switched on after insertion of the biosatellite into orbit. At this point the lighting and film equipment are turned on and the substrate and seeds are watered. The seedlings are to be constantly illuminated over the entire course of the experiment (about 20 days) and the camera will operate in the given mode (1 frame every 10 minutes). Atmosphere parameters in the installation will correspond to those of the internal environment in the biosatellite for the term of the experiment. The installation will be turned off before the return to Earth.

The vegetation bath and camera and film will be removed from the installation at the biosatellite's landing site. A part of the material will immediately be treated with chemical fixation agents, and one other part will be placed in melting ice. The remaining plants will be carried in a special transporting container.

It is proposed that analysis of the material provided to the laboratory be conducted using chemical and biochemical methods, as well as both light and electron microscopes.

4. "Mammalian Cell Cultures" /46

Mammalian cell culture experiments on the "Cosmos-368" and "Cosmos-782" biosatellites and "Salyut-6" and "Skylab-3" space stations have convincingly shown that space flight factors have no essential effect on animal cells in tissue cultures and do not cause noticeable structural changes and chromosome mutations. Some metabolic and physiological distinctions between flight culture variants and the respective laboratory controls have been described (differences in glucose utilization rates, according to data from American cytologists, and increase in average postflight cell nucleus diameters [F. V. Sushkov, et al.]).

The question of possible changes in cell reproduction rates in weightlessness still remains open. Common knowledge about the increased growth rates in cultures of infusoria, chlorella, and some other biological objects dictate the need for careful study of this phenomenon in more organized systems, such as mammalian cells. To this end, an experimental study of the effects of space flight on reproduction rates, some biometric indices, and the genetic apparatus of cells within the bodies of animals are planned for the next 1979 biological Earth satellite; also planned is the determination of possible reactions of weightlessness-adapted cells to Earth gravity when they reproduce during the postflight period.

Cultures of mammalian cells at the end of the lag- and beginning of the log-phase will be placed on the biosatellite and kept during flight at a (physiologically) permissible temperature of $30 \pm 0.5°$. This temperature regime will make it possible at the end of the flight to obtain a cell population at the beginning of the stationary phase.

After the flight, the cell cultures are to be transported to the /47 laboratory at a "stabilizing" temperature of 18-20°. Once in the laboratory, one part of the cultures will be fixed for cytological analysis, and another part will undergo subculturization for the study of postflight cell passages. Cultures taken from a single cell suspension will serve as controls, and will undergo the experiment and be kept

under identical conditions but not experience the influence of space flight factors.

Evaluation of the condition of the cultures will be conducted using the following criteria: a) density of cell populations; b) karyo- and cytometric data; c) chromosome identification with differential staining of their C, R, and S phase bands; and d) gene mutations.

The planned experiment will permit verification of the facts previously obtained and will provide additional information about the influence of space flight on cell division rates and the genetic apparatus of mammalian cells in tissue cultures.

5. "Somatic Embryogenesis of Plants" /48

This and the following "Crown Galls of Carrots" experiment were prepared by US specialists and will be conducted jointly with Soviet specialists. Performance of the experiments is the logical continuation of studies done by the authors on analogous bio-objects during the flight of the "Cosmos-782" artificial Earth satellite in 1975.

The initiators of the "Somatic Embryogenesis of Plants" experiment are Prof. A. Grigoryan and Prof. F Stewart from the New York State University at Stony Brook (USA). The basic goal of the experiment is the study of the capability of isolated somatic plant cells to develop normally in weightlessness, quantitative evaluation of growth processes, and the development of vegetative and generative organs from embryon to adult plant, both during flight and in the postflight period.

The ability of somatic cells to create viable embryos in weightlessness was demonstrated in an experiment previously conducted on the "Cosmos-782" artificial Earth satellite. In addition, however, postflight analysis of the material revealed a number of functionally reversible minor divergences from the norm.

Thus, the expediency of repeating this experiment stems to a great extent from the need to confirm or deny the regularity of the previously noted anomalies, as well as more fully to describe the embryogenic processes of higher plants in weightlessness.

The experiment will be conducted in a "BB-2M" special container, provided by Soviet sources. The biomaterial will be delivered in Moscow 5 days before the beginning of the experiment. Outfitting of the containers with biomaterial, delivery of the containers on board, and transportation from the landing site will be accomplished by Soviet specialists. Analysis of the material will be done in the USA.

6. "Crown Galls of Carrots" /49

The experiment will be conducted according to the proposal of US specialists (University of Colorado), under the overall leadership of Prof. R. Baker, in conjunction with the Division of Plant Physiology, Department of Biology at the Lomonosov Moscow State University (Department Chief -- Prof. M. V. Gusev).

The basic goal of the experiment is the continued study of the extended effects of weightlessness on the growth rate of crown galls and the intensity of metabolic processes in tumor cells. The need for continuing these studies was dictated also by some errors in the program previously carried out in experiments aboard the "Cosmos-782" artificial Earth satellite. (Because of an unforeseen deficit of water in the flight version, it was difficult to define the pure effect of weightlessness). A broad program of postflight materials analysis, using current biochemical and electron microscope methods, is foreseen. Primary attention in postflight analysis will be directed at study of the distribution and activity of cell enzymes.

The experiment will also be carried out in a BB-2M container. The biomaterial is to be conveyed to Moscow 5 days prior to the beginning of the experiment. Delivery of the container, placement on board, and transportation from the landing site is to be accomplished by Soviet specialists. Both the flight (experimental) and terrestrial (control) versions will be equally divided between US and USSR specialists for further laboratory analysis.

Postflight analysis will be performed at the Division of Plant Physiology, Lomonosov Moscow State University Department of Biology, and in laboratories at the University of Colorado, USA.

III. Radiobiological Research /50

The "Bioblock" Experiment

The primary goal of the Soviet-French radiobiological experiment is the study of the action of heavy cosmic radiation nuclei on various biological objects in order to evaluate the radiation hazards of protracted space flight.

Previous experiments on the "Cosmos-782" and "Cosmos-936" biosatellites showed a more pronounced decrease in invertebrate animal survivability and various structural alterations in the cell nuclei of plants which had been affected by heavy charged particles (HCP), as compared to bio-objects not affected by HCP.

Studies done aboard the "Cosmos-936" biosatellite in an assembly located on the external skin of the satellite and having a 0.2 to 0.017 g/cm^2 shielding, without correlation of HCP strikes, showed more significant changes in survivability for artemia salina, when compared to the survivability of a. salina from an assembly located within the biosatellite.

However, as a consequence of the relatively low intensity of charged cosmic radiation particle flow and the short duration of the flight, strikes on germ-targets (in seeds) were too few for statistical workup. Besides, the bio-objects in the external container were "scattered", so calculation of bio-objects affected by HCP could not be done. All of this complicated interpretation of the data obtained.

In order to determine the flow and charge and energy spectra of the heavy nuclei passing through the biological objects, as well as to localize radiation damage in the objects, plastic dielectric radiation detectors will be placed in layers beside the biological objects.

The external bioassemblies will be occupied by 8 cells measuring /51
40 X 14.5 mm, of which 4 are Soviet and 4 are French. The internal BB-1M bioassembly will consist of 2 automatic assembly-inserts from Soviet and French sources. Dismounting and scanning of the bioassemblies under terrestrial conditions will be conducted after the flight.

The results of the studies will permit us to evaluate the biological effects of heavy cosmic radiation particles behind minimal shielding in the range of 0.02-0.3 g/cm^2, and permit evaluation of the dependence of the radiobiological effect on cosmic HCP topography, according to criteria of: viability, development and cell structure of higher plants, and the survivability and development of artemia salina and unicellular algae ova.

The experiments to be conducted will enable us to obtain material for evaluation of the radiation hazards of cosmic radiation nuclei.

IV. Radiation Physics Research

MEGI-5 Experiment (Studies on an Electrostatic Shielding Module)

The basic goal of the experiment is the designing and development of technological and structural features for an electrostatic shielding (ES) module which acts like an actual shield, using the vacuum surrounding the space craft as an insulating medium, and the study of its energy characteristsics.

The experiments dealing with ES models which were conducted aboard the "Cosmos-605", Cosmos-690", "Cosmos-782", and "Cosmos-936" showed that it is possible, in principle, to create and maintain strong electrical fields (10^6 --$2 \cdot 10^7$ V/m) aboard space craft. A study of the electro-insulating properties of the vacuum surrounding the space craft demonstrated that conduction currents in the designated fields (where P ≈ 120 kV) do not exceed 10^{-13} amp/cm^2, i.e., maximum specific energy consumption for the operating voltages of high voltage transformers (considering efficiency) may lie in the range of 10^{-3} to 10^{-1} W/m^2. This makes the designing of an ES a real possibility, considering the energy resources currently available aboard space craft.

Hence, the next stage of work is the designing and technological development of the kind of ES element which would guarantee a high degree of reliability and simplify installation of the finished product, considering the complex geometry of the volume to be shielded and standardization of ES elements.

In view of the fact that regions of decreased electrical field would exist at the edges of adjoining elements, which could have an effect on the efficiency of the shielding module, it is necessary to choose the optimal shape for the individual module, such that the area /53 shielded would be maximized and the perimeter limiting this area minimized. Herein lie the structural features of the ES module.

The items enumerated above call for the development of a standardized ES element-module with a 300 kV high-voltage electrode. Grouping of such modules using a single source would permit total or partial shielding (depending upon the mission) of those portions of the space craft most vulnerable to radiation against the effects of electrons from the Earth's radiation belt and the bremsstrahlung generated by them.

Full-scale research on simulated ES modules permit us to determine experimentally the optimal practice (shakedown) regimes for high-voltage elements in order to adopt measures, if necessary, to reduce transition time to the operating regime and draw conclusions about structural features, weight-dimension characteristics, and energy consumption for actual ES modules. Calculations of background bremsstrahlung generated by conduction current electrons from the high-voltage vacuum interspace in the narrow shield of the module will be defined more precisely by the results of the experiment.

Inasmuch as ES make provisions for the presence of electronic supply, monitoring, and control units for the shielding, the choice of electronic devices needed for the construction of various electronic components for the ES plays an important part in ensuring functional reliability. This necessitates research into the effects of the environment in outer space on the reliability of electronic devices.

In addition, previous research on the electro-insulating properties of the vacuum surrounding space craft has shown that reliable operation/54 of the electro-vacuum devices used in space technology is possible when an air-tight envelope is lacking.

It is proposed that terrestrial experiments using models be carried out before research is done on the 1979 biosatellite. We propose doing studies at pressures in the range of 5×10^{-5} to 10^{-6} mm Hg, which corresponds to the pressure within the working volume of the electrostatic shielding module in space. This has been confirmed by direct pressure measurements in the MEGI-4 complex high-voltage chamber on the "Cosmos-936" biosatellite.

The technological principles for design of the module and extended maintenance of high voltage (up to 300 kV) in it, under vacuum conditions, must be worked out in terrestrial experiments. Previous experiments have indicated that, with voltages of up to 120 kV and specific field densities of $\simeq\simeq 10^7$ V/m, conditions within the high-voltage vacuum interspace are far from enough to cause breakdown. However, with further increase in voltage, even with specific field densities considerably lower than those which terrestrial measurements have shown to be safe, temporary instability and increases in leakage currents may be observed, which may be reflected in the operation of the module. Technical factors, such as the high voltage supply system, mounting of the high-voltage electrode, quality and geometry of the insulators, etc., also play a major role here. ES module assemblies developed during the process of terrestrial experiments will undergo testing for functional /55 reliability under actual conditions.

The general construction of the MEGI-5 complex is analogous to the MEGI-1 through MEGI-4 complexes used on previous biosatellite flights. The ES module and two assemblies for electronics reliability testing are to be installed on the outer surface of the biosatellite's instruments module. Control and complex data processing units will be located within the biosatellite.

The basic element of the complex is the internal high-voltage unit, containing a high-voltage source, electrode system (high-voltage electrode and narrow screen, located under the potential of the body), simulating the elementary cell of an actual ES, standard high-frequency device with detachable casing, and sensors for pressure, vacuum interspace current, and other auxiliary apparati.

The serviceability of the ES module at $\simeq$ 300 kV shield electrode operating voltage will be tested for the first time during the full-sclae experiment. The results of the experiment will allow us to make estimations and theoretical evaluations of the specific technological principles for construction of an ES module and its energy and weight-dimension characteristics.

In addition, recommendations concerning the use of standard electro-vacuum devices with pressurized capsules will be made.

Serviceability testing of a wide range of electronics devices will allow us to include them among those needed for functionally reliable ES. Direct measurements of the electro-insulating properties of the module at the given voltages will make it possible to evaluate the energy and weight-dimension characteristics of the module as a component element of the ES.

The "Dielectric Shield" Experiment /56

The goal of the experiment is testing of the protective properties of a dielectric shield on the biosatellite orbit. Previous experiments on the "Cosmos-690", "Cosmos-782", and "Cosmos-936" biosatellites, in which studies were done on the stability of the volume charge injected into the dielectric in an electron accelerator in open space conditions, and the methodology of measuring the doses on the capsule using thermoluminescent plates (TLP) was worked out.

It is proposed that the experiment on dielectric shielding (DS) aboard the 1979 biosatellite, as in previous experiments, be conducted in special containers which make it possible to install the subject material behind the skin of the biosatellite and expose them to outer space, with subsequent delivery to Earth.

The need to install the dielectric shielding elements behind the skin of the satellite in this experiment was dictated by the fact that the skin materially weakens the primary electron flow present on the satellite's orbit. Thus, when the DS elements are installed within the descent module, their shielding properities can only be tested by the comparatively low intensity high-energy component, which is, moreover, highly filtered by the skin layers. Besides this, considering the various possible applications for DS, it would be interesting to test these shielding properties over a wider range of energies.

Research done in biosatellite orbit has shown that the value of the dose, averaged both by detector sensitivity and time of flight, amounts to from dozens to hundreds of rads. Data obtained using thermoluminescent detectors have indicated, moreover, that the radiation is rather weak.

In accordance with the goals of the research, the plan of the /57 experiment is the following:

The plates are irradiated under controlled conditions in an electron accelerator and installed in the biosatellite's containers along with

the TLP dosimeters. Uncharged plates, also with dosimeters, are also installed here. Considering that the flow of penetrating radiation is several orders of magnitude lower than that of the electrons, the latter can be separated out without any particular difficulties.

Testing of the shielding properties of charged dielectrics against electron flow in Earth orbit will be conducted using dose-registration techniques developed in previous experiments, which were done with the aid of TLP and the use of the appropriate apparati.

The thicknesses of the sample plates were selected with consideration of electron spectra, and amount to, correspondingly, 0.5 mm, 1.5 mm, 3.0 mm, and 10 mm. One uncharged control plate will be installed for each three plates of a given thickness which were irradiated in the accelerator. Thus, it is proposed that, in all, eight dielectric shielding cells be used. All cells have a cylindrical shape with a diameter of 40 mm and a height of 14.5 mm.

The charge density given the plates will lie in the range of 10^{-6} to 2×10^{-6} coulombs/cm^2. Both before and after the flight, the value of the injected charge will be measured using apparati and methods developed in previous studies.

Postflight workup will be done in terrestrial conditions using the developed methodology.

The "Dose Characteristics behind Thin Shielding" Experiment /58

The goal of the reasearch on cosmic radiation dose characteristics consists of obtaining data about the weakening of cosmic radiation by thin layers (0.003 -- 1.500 g/cm^2) of material and about the doses present behind the given layers. There is virtually no data about such ranges of thickness. The work being planned is a continuation of research done on the "Cosmos-936" biosatellite.

The experiment concerning the weakening of cosmic radiation by thin shielding layers will be conducted, as proposed, in containers analogous to those used in the "Dielectric Shielding" experiment, which will make it possible to install the objects to be studied on the outer skin and expose them to outer space, subsequently returning them to Earth.

The need to install the dosimeters behind thin shielding layers on the outer surface of the space vehicle is dictated by the fact that the skin materially weakens the electron flow present in the orbit.

The plan of the experiment is as follows: the TLP dosimeters are installed in containers behind thin layers of shielding (0.003 -- 1.500 g/cm^2). Considering that the flow of penetrating radiation is several orders of magnitude smaller than the flow of electrons, the basic contribution in the integral dose will be given by electrons.

Assemblies with inserted TL detectors, screened on the open space side by shielding layers with quantified values (at not less than 4 points), will be installed in each container on special plates. Thermoluminescent dosimeters, thermoluminophors, and teflon TLD with /59 ≈ 200 micron thicknesses will be used as detectors.

Data about the weakening of dose in open space by thin shielding layers is planned to be obtained by the difference method.

Six cells are to be used for the aforementioned studies. All cells are cylindrical in shape, having a 40 mm diameter and height of 14.5 mm.

Measurement of the flight samples will be accomplished in terrestrial conditions on a standard thermoluminescence dosimeter measurement device. A curve showing the weakening of the dose by the thin layers and qualitative evaluation of the spectra of electrons in the biosatellite's orbit will be obtained as results of the studies.

Experiment on Radiation Shielding /60

The goal of joint Soviet-American experiment K-309 is measurement of the fluency of the low energy component of cosmic radiation heavy nuclei.

Joint experiments K-103 on the "Cosmos-782" and K-206 on the "Cosmos-936" biosatellites, done within the spacecraft, allowed us to obtain the characteristics of cosmic radiation behind shielding of 5 g/cm^2 and thicker. The low energy component under these conditions was completely absorbed by the skin of the space craft.

In order to have a reference between the fluencies within the craft and particle flow striking the exterior, analogous studies will have to be conducted on the outer skin.

These studies will be done in containers on the surface of the biosatellite. These containers make it possible to install dosimeters on the surface and expose them to space and subsequently return them to Earth.

The dosimeter assemblies (diameter 40 mm, height 14.5 mm) will be occupied by 6 cells (4 US and 2 USSR). A collection of baffled dielectric track detectors (cellulose nitrate, lavsan, polycarbonate, mica, and glass) will be included among the assemblies.

Monitor measurements of the high energy component of cosmic radiation heavy nuclei will be accomplished using three dielectric track detector units. The geometry of the assemblies and plan of their locations in the containers is analogous to that of the "Cosmos-690, /61
782, and 936" satellites, i.e., distribution of the assemblies will occur at places on the mounting plates which are not occupied by cells. Comparison of the data obtained will make it possible to study the dynamics of changes in the components in relation to solar activity.

Study of high-energy cosmic radiation components within the biosatellite will be conducted in a container analogous with that used in experiment K-206 on the "Cosmos-936" biosatellite (half of the assembly is US and half USSR). These studies, together with data from the surface of the biosatellite, will permit us to evaluate the shielding properties of the biosatellite's structure and envelope, as well as to obtain additional data about neutron flow.

Comparison with data from the "Cosmos-782" and Cosmos-936" biosatellites will make it possible to obtain data on temporal variations in heavy nuclei in cosmic radiation.

Development of exposed dosimeters will be done in terrestrial conditions using the standard methododlogy.

As a result of the studies, fluencies and spectra of cosmic radiation heavy nuclei in a range of charges from $6 \leq Z \leq 26$ and energies of 50 -- 400 MeV/nucleon should be obtained.

The "Heat Exchange-I-I" Experiment /62

The "Heat Exchange-I-I" experiment is being conducted in order to study the effects of weightlessness on the process of heat exchange between a heated surface and the surrounding medium (air).

An apparatus developed and prepared by Czech specialists will be used for the experiment. It contains:

--an electrical dynamic kata-thermometer;
--a tunnel with a fan for creating calibrated blower speeds;
--electronic control unit.

The device is constructed in the form of a single block, permitting necessary measurements both with a motionless surrounding medium and with small (up to 0.8 m/sec) blower speeds.

The device turns on when it is fed 27V from a constant-flow source. No later than 2 minutes after the surrounding temperature reaches 20 -- 25°C, the temperature on the surface of the electrical dynamic kata-thermometer transducer is set at 37 $\pm$ 1°C. This temperature is maintained by a built-in electrical heater. The electrical output necessary for this set regime depends upon the speed of the blower and the temperature of the surrounding medium.

In conformity with the program of the experiment, the device is turned on every 2 hours every other day of the biosatellite's flight, and every cycle of measurements does not exceed 15 minutes.

Measurement of electrical output for transducer heating and surrounding medium temperature is conducted in each cycle of operation for the device. Information on the heating conditions in the device, in the form of voltage levels from 10 to 6V, goes into a recording device on board. Deciphering and workup of this information will be /63 accomplished at the end of the flight of the biosatellite.

Comparison of results from the flight experiment and those from the terrestrial control will permit establishment of differences in the cooling properties of pressurized cabins in the biosatellite and on Earth.

This experiment is a further development of analogous studies done on the flight of the "Cosmos-936" biosatellite.